CLAIMS

1. A multi-tone modem with a plurality of components forming a transmit path and a receive path; and the receive path components of the multi-tone modem comprising:

a fast Fourier transform (FFT) component to convert multiple received tones in a time domain to successive symbols in a frequency domain, with each of the successive symbols including pilot sub-symbols together with message sub-symbols;

a message processor coupled to the FFT and the message processor operable to select pairs of message and pilot sub-symbols in each symbol and to equalize the message sub-symbol with the pilot sub-symbol in each pair of sub-symbols to substantially remove from the message sub-symbol frequency dependent phase shifts between the tones of each symbol; and

a decoder coupled to the message processor for decoding each message sub-symbol equalized in the act of equalizing to the corresponding message data.

2. The multi-tone modem of Claim 1, wherein the message sub-symbol and the pilot sub-symbol correspond with a message tone and a pilot tone adjacent to one another in the frequency domain.

3. The multi-tone modem of Claim 1, wherein the message processor further comprises:

a pseudo-equalizer for multiplying the message sub-symbol times the complex conjugate of the pilot sub-symbol in each pair of message and pilot sub-symbols to substantially remove from the message sub-symbol the frequency dependent phase shifts therein.

4. The multi-tone modem of Claim 1, further comprising:

a frequency domain equalizer (FEQ) coupled to the FFT in parallel with the message processor and the FEQ operable during the training phase of operation to

determine a coefficient vector with an inverse frequency response of a communication channel using the pilot sub-symbols from the FFT.

5. The multi-tone modem of Claim 1, wherein the message processor further comprises:

a de-scrambler to de-scramble the message sub-symbols and the pilot sub-symbols to remove effects of any scrambling thereof during transmission.

6. The multi-tone modem of Claim 1, wherein the message processor further comprises:

a de-scrambler for asymmetrically de-scrambling the message sub-symbols and the pilot sub-symbols with the asymmetrical de-scrambling resulting in each message sub-symbol and pilot sub-symbol exhibiting a fixed phase bias; and

wherein the decoder further decodes each message symbol with a decoding table which removes the fixed phase bias imparted by the de-scrambler.

7. The multi-tone modem of Claim 1, wherein the message processor further comprises:

a diversity combiner for combining selected ones of the equalized message sub-symbols redundant with respect to one another in terms of the message data encoded therein to produce at least one unique message sub-symbol with a reduced noise level therein; and

wherein the decoder further decodes the at least one unique message sub-symbol to the corresponding message data.

8. A method for demodulating data received over a communication medium with a communication channel with multiple pilot tones with pilot data modulated thereon and message tones with message data modulated thereon; and the method for demodulating comprising:

converting the received data from a time domain to a frequency domain with the received data in the frequency domain including successive symbols each including pilot sub-symbols together with message sub-symbols;

selecting pairs of message and pilot sub-symbols in each symbol;

equalizing the message sub-symbol with the pilot sub-symbol in each pair of sub-symbols to substantially remove from the message sub-symbol frequency dependent phase shifts imparted to the communication channel; and

decoding each message sub-symbol equalized in the act of equalizing to the corresponding message data.

9. The method for demodulating of Claim 8, wherein the message sub-symbol and the pilot sub-symbol correspond with a message tone and a pilot tone adjacent to one another in the frequency domain.

10. The method of Claim 8, wherein the equalizing act further comprises the act of:

multiplying the message sub-symbol times the complex conjugate of the pilot sub-symbol in each pair selected in the act of selecting to substantially remove from the message sub-symbol the frequency dependent phase shifts therein.

11. The method of Claim 8, further comprising the act of:

determining in parallel with the equalizing act, a coefficient vector with an inverse frequency response of a communication channel using the pilot sub-symbols converted in the converting act.

12. The method of Claim 8, wherein the act prior to the selecting act of:

de-scrambling the message sub-symbols and the pilot sub-symbols to remove effects of any scrambling thereof during transmission.

13. The method of Claim 8, wherein the act prior to the selecting act further comprises:

asymmetrically de-scrambling the message sub-symbols and the pilot sub-symbols with the asymmetrical de-scrambling resulting in each message sub-symbol and pilot sub-symbol exhibiting a fixed phase bias; and

wherein further the decoding act further comprises decoding each message symbol with a decoding table which removes the fixed phase bias imparted in the asymmetrical de-scrambling act.

14. The method of Claim 8, further comprising the act prior to decoding act of:

combining selected ones of the message sub-symbols equalized in the act of equalizing, with the selected ones of the message sub-symbols redundant with respect to one another in terms of the message data encoded therein to produce at least one unique message sub-symbol with a reduced noise level therein; and

with the decoding act decoding the at least one unique message sub-symbol to the corresponding message data.

15. The method of Claim 8, wherein the communication channel established over the communication medium exhibits a Digital Subscriber Line (DSL) protocol implemented with a discrete multi tone (DMT) modulation.

16. The method of Claim 8, wherein the communication medium comprises one of a wired medium and a wireless medium.

17. A method of modem training between at least two modems comprising the steps performed at a receiving one of the at least two modems of:

converting a training set of pilot tones and message tones from a time domain to a frequency domain with the received data in the frequency domain including successive training symbols each including pilot sub-symbols together with message sub-symbols;

selecting pairs of message and pilot sub-symbols in each training symbol;

equalizing the message sub-symbol with the pilot sub-symbol in each pair of sub-symbols to substantially remove from the message sub-symbol frequency dependent phase shifts between the tones of each training set; and

decoding each message sub-symbol equalized in the act of equalizing to the corresponding message data.

18. The method of modem training of Claim 17, wherein the message sub-symbol and the pilot sub-symbol correspond with a message tone and a pilot tone adjacent to one another in the frequency domain.

19. The method of modem training of Claim 17, wherein the equalizing act further comprises the act of:

multiplying the message sub-symbol times the complex conjugate of the pilot sub-symbol in each pair selected in the act of selecting to substantially remove from the message sub-symbol the frequency dependent phase shifts therein.

20. The method of modem training of Claim 17, further comprising the act of:

determining a coefficient vector with an inverse frequency response of a communication channel using the pilot sub-symbols converted in the converting act.

21. The method of modem training of Claim 17, wherein the act prior to the selecting act of:

de-scrambling the message sub-symbols and the pilot sub-symbols to remove effects of any scrambling thereof during transmission.

22. The method of modem training of Claim 17, wherein the act prior to the selecting act further comprises:

asymmetrically de-scrambling the message sub-symbols and the pilot sub-symbols with the asymmetrical de-scrambling resulting in each message sub-symbol and pilot sub-symbol exhibiting a fixed phase bias; and

wherein further the decoding act further comprises decoding each message symbol with a decoding table which removes the fixed phase bias imparted in the asymmetrical de-scrambling act.

23. The method of modem training of Claim 17, further comprising the act prior to decoding act of:

combining selected ones of the message sub-symbols equalized in the act of equalizing, with the selected ones of the message sub-symbols redundant with respect

to one another in terms of the message data encoded therein to produce at least one unique message sub-symbol with a reduced noise level therein; and

with the decoding act decoding the at least one unique message sub-symbol to the corresponding message data.